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All plasma processes share a common problem that affects yield. Abnormal electric discharges can create particulate matter and cause physical and/or electrical damage to the wafer. Such discharges can also cause the resulting plasma to be unstable.

A group of researchers determined that they could effectively detect and suppress anomalous discharges in plasma equipment using the signals from two probes that can predict the occurrence of abnormal discharges. The discharges are then suppressed by the voltage applied to the electrostatic chuck in a reactive ion etch (RIE) system. Report findings at the recent IEEE International Symposium on Semiconductor Manufacturing were M. Yasaka (currently at the Ariake National College of Technology in Fukuoka, Japan) colleagues with the Tokyo Cathode Lab (Kumamoto, Japan), NEC Electronics, the Kun Industrial Research Institute and the Kyushu Institute of Technology.

The researchers used two sensors: an acoustic emission (AE) sensor and a view-port (VP). The VP probe was specifically designed for this application and is able to detect change in potential just prior to anomalous electrical discharge. The AE sensor detects the acoustic signal emitted from the point where the discharge occurred. The detection of a supersonic wave is independent of plasma generation method (DC or RF).

The VP probe uses a transparent electrode film made of indium tin oxide, which is positioned between the inner, thin quartz glass and the outer, thick glass of the RIE system's view-port. The VP probe detects a difference in charge buildup at the inner glass surface of the viewing port. The AE detectors are able to monitor the occurrence of abnormal discharge, and can also be used to determine the location of the discharge by analyzing the acoustic signals detected by multiple AE sensors attached at different locations inside the process tool. The AE sensor was attached to the RIE tool with three AE sensors located around the periphery of the chamber. The tool used an in situ particle monitoring system capable of detecting titanium particles >70 nm.

The parallel-plate RIE system used 13.56 MHz excitation voltage, and anomalous discharges were induced using moisture on a titanium-coated wafer mounted on the RF electrode by an electrostatic chuck (ESC) with helium backside cooling. RF power of 1000 W was supplied. Gases used were  $\text{C}_4\text{F}_8$  and  $\text{SiF}_4$ . The discharge pressure was 30 Pa. The researchers monitored the AE and sensor signals using a multichannel digital data recorder.

Monitoring showed the VP probe was very sensitive to change in electrical potential, showing a sharp drop in potential just prior to the discharge.

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negative output voltage (Figure ). This indicates that the flux of electron flow from the pl increased at the moment that the anomalous discharge occurred. The anomalous discharge is a plasma state where the plasma density and/or electron temperature was higher than the normal state. The AE sensor detected the change in potential just milliseconds after the VP probe signal, indicating the propagation delay of the AE wave along the chamber wall.



**Signal waveform of the view-port probe shows that the indicating signal appears prior to the anomalous discharges.**

Moisture in the chamber caused abnormal discharges to occur ~3 sec apart for 10 min. When the wafer was replaced with another wafer with moisture, the same phenomena occurred. The particle monitor was coincident with the AE sensor and VP probe signals.

The group determined that, by lowering the voltage applied to the ESC wafer stage, fewer discharges occurred. Therefore, they developed an electric feedback system that controls the ESC voltage using the foreseeing signal as a trigger. The system consists of an A/D converter, the ESC voltage and an electronic system that records the discharge signals and analyzes the position of the abnormal discharge points.

The feedback system responds to the foreseeing signal of the VP probe and applies voltage to the ESC. When the ESC voltage control is employed, the anomalous discharge is completely suppressed.

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